ANNALS OF SURGERY

VOL. XLII JULY, 1905 No. 1

ORIGINAL MEMOIRS.

OF LIGATURE OF THE INNOMINATE ARTERY.

WITH REPORT OF A SUCCESSFUL CASE.

BY WILLIAM SHEEN, M.S., M.D. (LOND.), F.R.C.S. (ENG.),

OF CARDIFF, ENGLAND,

Honorary Surgeon, Cardiff Infirmary; Consulting Surgeon, Seamen's Hospital, Cardiff.

1. *Introduction.*—Prior to the present case, ligature of the innominate artery had been performed successfully seven times, viz., three times in the United Kingdom, three times in the United States, and once in India. The writer's case, therefore, seems worthy of record, and a study of the literature of the operation leads further to the conclusion that the process of collecting and commenting upon the accounts of previously recorded cases will also be instructive and will form an interesting chapter of surgical history. This, therefore, has been carried out, and every effort has been made to render the collection of cases complete, and to omit no essential points in their record. In spite of its previous high mortality, the operation is one which, under modern surgical conditions, the writer believes has a safe and useful future.

2. *Summary of Present Case.*—The patient, a man aged forty-six years, a laborer, formerly a soldier, was admitted to the Cardiff Infirmary on February 2, 1904. He had an aneurism of the second and third parts of the right subclavian artery, the symptoms of which commenced six months previous to admission. On March 31, 1904, the innominate and the right common carotid

arteries were tied. Pulsation ceased in the aneurism, but was found to have returned to some extent on the following day. On May 19 an unsuccessful attempt was made to again tie the innominate. On June 2 the second part of the subclavian was tied close up to the aneurism. Recovery took place with consolidation of the aneurism, and the man remained well when last seen, eight and one-half months after the first operation.

3. *Account in detail of Present Case.*—W. T., male, aged forty-six years, admitted to the Cardiff Infirmary, February 2, 1904, being sent by Dr. T. W. Thomas, of Caerphilly, near Cardiff.

History.—Laborer since 1885; previous to that in the army, having served in the Bermudas and in the Egyptian campaign of 1882-1884. No history pointing to venereal disease. Has heavy straining work to do. Has never had a blow at the site of the aneurism. Admits alcoholism.

Present Trouble.—This began six months before admission, with numbness and tingling in the right hand; these symptoms have persisted and become more marked, the numbness and tingling extending up the arm. Sometimes the pain in the arm is so great that he cannot raise his hand to his head. He did not notice the swelling until January 27 (six days before admission), and he attributes its presence to a "jar of the hammer" with which he was working on that day. He worked until January 30, then reported himself ill, and was sent to the Infirmary.

On Admission.—The general appearance is shown by the photograph (Fig. 1). He is a fairly strongly built man, but pallid and with flabby muscles.

Aneurism.—Pulsating swelling above clavicle in situation shown in photograph; projects more from the general surface, and is more marked in all respects when the patient sits up than when he is lying down; pulsation heaving, expansile, not forcible; systolic bruit; slight rise and fall during respiration; general form circular, with an upward and outward expansion; greatest breadth, 6 centimetres; height of upper margin above clavicle, 5 centimetres; centre raised above general surface 1.5 centimetres; overlapped anteriorly by sternomastoid and posteriorly by trapezius; lower margin lies behind clavicle, but finger can be got between clavicle and swelling; pressure causes shooting-pains in axilla; no dulness over manubrium sterni.

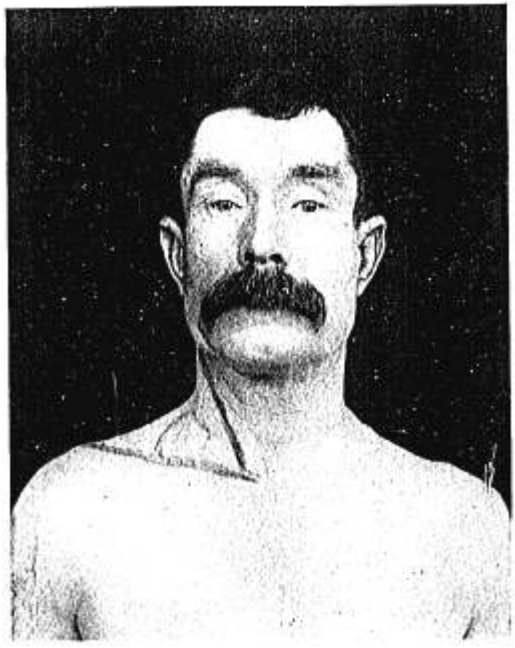

FIG. 1.—The patient before operation. The outline of the aneurism, the upper border of the clavicle, and the inner margin of the sternomastoid have been marked in India ink.

Pressure Symptoms.—The radial pulse is only just perceptible, requiring great care in order to feel it; the same observations apply to the brachial and axillary pulses; the radial pulse-rates are equal; there is no difference between the carotid or the temporal pulses on the two sides.

The veins are slightly dilated over the upper and outer part of the right chest and over the front of the right shoulder; there is a dilated vein running up the front of the arm over the middle of the biceps muscle. There is no œdema of the arm.

There is pain over the scapula. Tingling pains run down the arm from the axilla. "Dead fingers" and "cramps" are complained of in the hand. The fingers of the hand have a bluish-white, "dead" appearance as compared with those of the opposite side. The pupils are equal and react to light and accommodation. There is no alteration in the voice and no cough.

Other Symptoms.—Heart. Apex beat palpated with difficulty in fifth space in nipple line; otherwise normal. Arteries not atheromatous. Left radial pulse good volume; rate, 66. Lungs normal; breathing quiet, sixteen to the minute; no expectoration. Occasional dyspeptic symptoms,—pain and flatulence. Slight enlargement of liver. Urine normal. No swelling of feet. Evidence of venereal disease, none. The whole body was carefully examined.

Subsequent progress prior to operation. The patient was found to be suffering from scabies, with the accompanying eczema and numerous "boils" about the body and limbs. This necessitated a prolonged course of treatment. The aneurism increased slightly in size. The pressure symptoms varied from day to day, but underwent no marked exacerbation. The patient was usually allowed up daily and had a generous diet without stimulants.

Operation, March 31, 1904, two months after admission. The greatest care was taken to secure asepsis. The preparation of the patient's skin was commenced forty-eight hours before the operation. The operator, assistants, and nurses wore sterilized cotton gloves, and were clothed in sterilized linen overalls. The anæsthetist was screened off by a sterilized linen cloth stretched over a copper wire framework. Only the situation for the incision and the skin immediately adjacent were exposed, the sterilized cloths being stitched to the skin around this area. Pieces of sterile gauze were used for swabs. Knives and scissors were

sterilized by immersion in and wiping with carbolic lotion; other instruments by boiling. Needles had been previously prepared, and were stored in absolute alcohol. With the exception of the silk used for the innominate itself, ordinary Chinese twist was used throughout for ligatures and sutures, which had been prepared by boiling and was stored in absolute alcohol.

Chloroform was administered by Dr. F. W. S. Davies. Mr. William Martin, Assistant Surgeon to the Infirmary, and Mr. Brownlee, Resident Medical Officer, assisted the operator.

A median incision was made five inches long, extending from over the cricoid cartilage to an inch below the sternal notch. The cervical fascia was divided, and the sternolaryngeal muscles separated in the middle line and drawn apart throughout the length of the incision. The lateral lobes and the isthmus of the thyroid were exposed in the upper part of the wound. The operator, who had been standing on the right, now crossed over to the patient's left side and worked standing near to the patient's left shoulder. The dissection was carried well into the sternal notch, and a long process of tissue, probably remains of the thymus gland which lay laterally along the right side of the trachea, was removed. This process showed communicated pulsation, and was at first thought to be the carotid. The carotid sheath was next identified and opened, and the carotid followed down to the bifurcation; in doing this the thyroidea ima vein had to be divided between two ligatures. An attempt was now made to clear and identify the first part of the subclavian, it being thought it might be possible to apply a ligature to this; but, while a long narrow-bladed retractor was being adjusted to open out the lower and outer angle of the wound, a slight hissing sound occurred from this situation, indicating probably wound of the pleura: this ceased on packing in a gauze plug, but recurred when the gauze was removed. The patient gave no signs of being affected by the incident. The gauze being left in, the dissection was carried to the innominate, about half an inch of which was exposed lying obliquely against the right side of the trachea, and by means of a right-angled needle (Macewen's hernia needle) a ligature of stout floss-silk (Down Brothers, London, No. 2 pearl silk) was carried round the vessel from without inward. There was no especial difficulty about this performance, and no means of illuminating the situation of ligature additional to the ordinary daylight in the operating theatre

were needed. The silk was passed double round the artery, and the two ligatures thus provided were tied in Ballance's "stay knot," the first turn of a reef being taken in each in the same direction, and then the knot completed by treating the two ends on each side as one in making the second turn. The intention in tightening the ligature was to occlude the artery without injuring its coats. A fair amount of force was required before the pulsation in the aneurism ceased. On tightening, the anæsthetist observed the disappearance of the temporal pulse, and also noted that there was no increase of pallor on the right side of the face, no sweating of the face, and no change in the right pupil. The carotid was found flaccid, empty, and not pulsating, and a single length of Chinese twist was tied round it in a "surgical knot."

The parts fell together easily. The sternolaryngeal muscles and the cervical fascia were brought together by interrupted sutures. The hissing sound referred to above returned when the gauze plug was removed, but ceased on the application of the deep sutures. The skin wound was closed with a continuous silk suture without drainage, and sealed with sterile gauze and collodion, over which sterile gamgee tissue was fastened with broad bands of strapping. The operation lasted nearly two hours. Some time was lost owing to the patient several times partly coming round from the anæsthetic. It was impossible for the anæsthetist to observe the patient properly when he was screened off in the way above mentioned. Great caution also was observed in the various steps of the operation.

On recovering from the anæsthetic, the patient was extremely restless, requiring two nurses to restrain him, chattering nonsense, and not recognizing those about him. He was given sips of milk and water and vomited twice. At 7 P.M. his temperature was 98° F.; pulse, 88; respirations, 24. At 8.30 P.M. he was given one-quarter grain of morphia hypodermically, after which he was quieter and slept at intervals, complaining of great pain in the region of the heart when awake. The mental disturbance and restlessness continued for the next two days, gradually abating. On the morning of the day following the operation a slight return of pulsation was noted in the aneurism; this became more forcible during the next three or four days, diminished again for an equivalent period so as to be almost imperceptible, then returned again and remained, but was never so forcible as

before the operation, while the aneurism had a more solid feel. The right radial pulse could not be detected, and its return was not noted until May 17, when it could be just felt as before the operation. The wound ran a perfectly aseptic course. The sealed dressing was taken off on the eighth day and the stitches removed. All dressings were left off on the twelfth day. Temperature never above 99° F.; pulse only once above 90; respiration, normal rate. No chest disturbances. On April 14, a fortnight after the operation, the patient got up. Later he had a slight attack of tonsillitis, but on the subsidence of that his general health remained good. The pain down his arm and other pressure symptoms continued. My colleague, Dr. D. R. Patterson, kindly examined his larynx on April 26, and reported slight want of mobility of the right vocal cord. During May the patient had epigastric pain and other dyspeptic symptoms. These were to a large extent accounted for when on one occasion he was found dead drunk in the hospital garden, the absence of his radial pulse much alarming the nurse who was first called to him.

Second Operation.—This was performed on May 19. Dr. Davies gave the anæsthetic, and precautions similar to those on the previous occasion were observed with regard to asepsis. The old wound was reopened, the incision over the sternum being carried somewhat lower. The procedure was more difficult and tedious than on the former occasion on account of the cicatricial tissue present. The former ligature round the innominate was identified, and half an inch of the vessel exposed on its cardiac side. On passing the point of the Macewen's needle threaded with Chinese twist outside and then behind the vessel there was an alarming gush of blood filling up the wound. On withdrawing the needle the bleeding ceased. Several attempts were made to pass the needle, but always with the same result. It was thought that the innominate vein or one of its tributaries was wounded, these parts having become adherent to the artery as a result of the first operation. The first part of the subclavian could be felt pulsating; but it would have been difficult to define, owing to the new tissue formation, and there would have been great risk of injuring the pleura. The wound was closed as before, without drainage, and sealed.

Third Operation.—Recovery from this operation was absolutely uneventful, and on June 2 the third operation was per-

formed under similar conditions to the previous ones. A transverse incision five inches long was made above the clavicle directly over the aneurism. After incision of the fascia various superficial veins, including a large external jugular, were divided between two ligatures. The outer edges of the sternomastoid and scalenus anticus were identified and cleared. The omohyoid was a little puzzling at first, forming a long whitish cord bound down, as far as it appeared in the wound, to the clavicle: after recognition it was divided. Another large vein running deeper to and parallel to the external jugular was tied and divided. The more difficult part of the operation now commenced, the pulsating aneurism filling up the wound. The sternomastoid being retracted, the dissection was carried down between the inner side of the aneurism and the scalenus anticus, and, the latter muscle being also retracted, a small portion of artery internal to the aneurism was exposed: the artery appeared healthy and the aneurism sprang suddenly off it, having a globular form and so situated that the artery entered the internal and posterior part of the aneurismal sac. The phrenic nerve, which was clearly exposed on the surface of the scalenus, being retracted, the outer half of the scalenus was divided transversely with scissors: no disturbance of respiration took place during the process. The aneurism being held outward and the partly divided scalenus further retracted, about three-quarters of an inch of the artery was exposed and cleared: it was somewhat difficult to get a needle round, as the left hand of the operator was partly occupied in retracting the aneurismal sac, which otherwise bulged over the artery, completely hiding it. A ligature of stout (No. 4) Chinese twist was passed round the artery about half an inch from the sac and tied in a "surgical knot." Pulsation in the aneurism ceased. A second similar ligature was passed and tied distal to the first, close up against the sac. The wound was kept bloodless throughout; the parts fell together, leaving no pockets; superficial structures and skin were brought together as in previous operations, and the wound sealed without drainage.

Recovery was uneventful. The patient was restless, inclined to sit up and turn about, and had to be constantly watched. The arm was kept wrapped in wool for a week: it was not so pink under the nails as on the other side, otherwise the circulation was unaffected. There was no pulse in the arteries of the limb. The

4.—TABULAR STATEMENT OF CASES.

No.	Operator.	Place and Date of Operation.	Sex and Age of Patient.	Disease and its Duration.	Incision.	Vessels Tied.	Material of Ligature and Kind of Knot.	Result.
1	Valentine Mott.	New York Hospital, May 11, 1818.	Male, 57.	Traumatic subclavian aneurism; 2½ months.	Mott's.	Innominate.	Round silk.	Death, 26th day; sepsis; hæmorrhage.
2	Graefe.	Berlin University Clinic, March 15, 1822.	Male, 30.	Subclavian aneurism; "rapid growth."	Inner border sterno-mastoid.	Innominate.	.....	Death, 67th day; sepsis; hæmorrhage.
3	Norman.	United Hospital, Bath, 1824.	Male.	Subclavian aneurism.	.....	Innominate.	.....	Death, 5th day; acute pericarditis.
4	Arendt.	Iwanhoff Hospital, St. Petersburg, 1827.	Male, 36.	Subclavian aneurism; ? traumatic; 1 year.	Inner border sterno-mastoid.	Innominate.	.....	Death, 8th day; sepsis.
5	Hall.	Baltimore Hospital, September 7, 1830.	Male, 52.	Subclavian aneurism; 9 months.	.....	Innominate.	.....	Death, 5th day; sepsis; hæmorrhage. Needle passed through vessel.
6	Bland.	Benevolent Asylum, Sydney, New South Wales, March 26, 1832.	Male, 31.	Subclavian aneurism; 2 years.	Mott's.	Innominate.	Ligature consisted of "two threads."	Death, 18th day; sepsis; hæmorrhage.
7	Bujalsky.	Military Hospital, St. Petersburg, May 11, 1833.	Male, 56.	Subclavian aneurism.	.....	Innominate.	Tied by "tourniquet."	Death, 5th day; sepsis.
8	Bujalsky (second case).	.....	.....	Subclavian aneurism ?.	.....	.....	... .	Death.
9	Quoted by Dupuytren.	Paris.	.....	Subclavian aneurism ?.	.....	.....	.....	Death, 3d day; hæmorrhage.

10	Lizars.	Royal Infirmary, Edinburgh, May 31, 1837.	Male, 30.	Traumatic subclavian aneurism; 11 months.	Inner border sterno-mastoid.	Innominate.	.....	Death, 21st day; sepsis; hæmorrhage.
11	Hutin. (Paris.)	1842.	Male, 27.	Wound of branch of axillary, 9 days.	.....	Innominate.	Flat ligature.	Moribund; death in 11 hours.
12	R. T. Gore.	United Hospital, Bath, September, 24, 1856.	Male, 52.	Subclavio-axillary aneurism; 3 years.	Mott's.	Innominate.	"Hempen ligature."	Death, 17th day; sepsis; hæmorrhage.
13	Pirogoff.	St. Petersburg, 1856.	Male, 46.	Subclavian aneurism; some years.	.....	Innominate.	.....	Death, 48 hours; acute sepsis.
14	Cooper.	San Francisco, 1859.	Male.	Innominate, subclavian, and carotid aneurism.	Mott's summit of sternum and sternal end of clavicle removed.	Innominate.	.....	Death, 9th day; kidney disease.
15	Cooper (second case).	San Francisco, 1861.	Male.	Subclavian aneurism ?.	Ditto.	Innominate.	.....	Death, 34th day; sepsis; hæmorrhage.
16	A. W. Smyth.	New Orleans Hospital, May 15, 1864.	Male, 33.	Subclavian aneurism; 3 months.	Mott's.	Innominate; carotid later; vertebral.	.....	Recovery after sepsis and hæmorrhage; aneurism recurred; died April 6, 1875.
17	Lynch.	New York, 1867.	Male.	Gunshot wound of internal carotid and vertebral.	.....	Innominate.	....	Death, 12th day; hæmorrhage.
18	E. R. Bickersteth.	Liverpool Royal Infirmary, May 7, 1868.	Male, 40.	Subclavian aneurism; 3 weeks.	Mott's.	Innominate.	Lead clamp, then silk.	Death on 6th day; hæmorrhage.
19	A. B. Mott.	New York, August 13, 1868.	Male.	Subclavian aneurism.	Mott's.	Innominate.	.....	Death, 23d day; sepsis; hæmorrhage.
20	S. B. Partridge.	Medical College Hospital, Calcutta, May 2, 1870.	Male.	Aneurism of carotid; carotid tied 13 days previously; 1½ years.	.....	Innominate.	.....	Moribund; death in 1½ hours.

4.—TABULAR STATEMENT OF CASES.—CONTINUED.

No.	Operator.	Place and Date of Operation.	Sex and Age of Patient.	Disease and its Duration.	Incision.	Vessels Tied.	Material of Ligature and Kind of Knot.	Result.
21	E. S. O'Grady.	Dublin, 1873.	Male.	Subclavio-axillary aneurism; 3 years.	Inner two inches of clavicle removed.	Innominate; carotid.	.....	Death in 20 hours; serous effusion into cerebral ventricles.
22	G. Buchanan.	Western Infirmary, Glasgow, June 1, 1880.	Male, 40.	Subclavian aneurism; 4 months.	Mott's.	Innominate.	.....	Death in a few minutes.
23	W. Thomson.	Richmond Hospital, Dublin, June 9, 1882.	Male, 49.	Subclavian aneurism; 10 months.	Mott's.	Innominate.	Ox aorta; 3 knots.	Death, 42d day; sepsis; hæmorrhage.
24	W. M. Banks.	Royal Infirmary, Liverpool, February 26, 1883.	Male, 50.	Subclavian aneurism.	Mott's.	Innominate.	Kangaroo tendon; 3 knots.	Recovery; return of pulsation 67 days later; ligature of subclavian; death.
25	Bull.	New York, 1884.	.....	Subclavian aneurism.	.....	Innominate; carotid; vertebral.	Double catgut ligatures.	Death, 33d day; hæmorrhage.
26	Bennett May.	Queen's Hospital, Birmingham, March 27, 1886.	Male, 30.	Subclavian aneurism; 17 months.	Mott's.	Innominate.	5 or 6 catgut threads; 3 knots.	Death, 18th day; sepsis; hæmorrhage.
27	Francesco Durante.	Operator's Clinique, Rome, March 25, 1887.	Male, 45.	Subclavian aneurism; 2 years.	Mott's.	Innominate; carotid; vertebral.	.....	Death, 15th day; sepsis; hæmorrhage.
28	J. Lewtas.	Murdan Hospital, Punjaub, India, May 13, 1889.	Male, 20.	Traumatic subclavian aneurism; 1 month.	Mott's.	Innominate; carotid.	Catgut.	Recovery; left hospital in 43 days.

29	G. E. Twynam.	Prince Alfred Hospital, Sydney, N. S. W., 1889.	Female, 18.	Traumatic subclavian aneurism; 1 month.	Median.	Innominate; carotid.	Silk.	Death in 18 hours from cerebral lesion.
30	W. H. A. Jacobson.	Guy's Hospital, London, February, 1890.	Male, 46.	Subclavio-axillary aneurism; 1 year.	Mott's; inner end of clavicle removed.	Innominate; carotid.	Ox aorta.	Death, 10th day; bronchopneumonia; delirium.
31	C. Coppinger.	Mater Misericordiæ, Dublin, January 9, 1893.	Male, 53.	Subclavio-axillary aneurism.	Mott's.	Innominate; carotid.	Silk.	Recovery on July 4, 1895; no sign of aneurism.
32	C. J. Symonds.	Guy's Hospital, London, November 5, 1894.	Male, 53.	Subclavio-axillary aneurism.	Two vertical incisions joined by transverse one above clavicle.	Innominate; carotid.	Floss-silk.	Recovery. Died later of other causes.
33	H. L. Burrell.	City Hospital, Boston, January 15, 1895.	Male, 54.	Subclavian aneurism; 18 months.	Mott's; sternoclavicular joint and part of sternum removed.	Innominate.	Silk reef knot.	Recovery. Died, 104th day from heart and arterial disease.
34	B. Farquhar Curtis.	St. Luke's Hospital, New York, December 2, 1899.	Male, 53.	Subclavio-axillary aneurism; "some months."	Median; splitting of manubrium.	Innominate.	Chromic catgut, 2 threads tied simultaneously, then single thread distally.	Recovery. Some sepsis; pulsation returned; carotid and first part of subclavian tied March 13, 1900; recovery.
35	C. A. Ballance.	St. Thomas's Hospital, London, April 15, 1902.	Male, 35.	Innominate subclavian and carotid aneurism; 6 months.	Median; splitting of manubrium.	Innominate; carotid.	Gold-beaters' skin; stay knot.	Death next day. Thrombosis of middle cerebral artery.
36	William Sheen.	Cardiff Infirmary, Wales, March 31, 1904.	Male, 46.	Subclavian aneurism; 6 months.	Median.	Innominate; carotid.	Floss-silk; "stay knot."	Recovery. Pulsation returned; ligature of subclavian, June 2, 1904; recovery.

wound was unsealed and the stitches removed on the ninth day, and all dressings were left off on the thirteenth day.

Three weeks after the operation there was no return of pulsation in the aneurism, which was hard and slightly tender. The pain down the arm was much less, and the tingling had disappeared; there was still slight numbness complained of in the tips of the fingers. On June 27 the patient got up, and on July 27 he left the hospital. He was kept under my personal observation until the middle of December, 1904, when he left Cardiff to live in Portsmouth. Marked pulsation was at first felt at the root of the neck over the innominate bifurcation, but this grew gradually less and less forcible, while the aneurismal sac became smaller and harder. The radial pulse reappeared faintly about two months after the operation.

Detailed examination on December 16, eight and one-half months after the first operation, shows the sac as a flattish, slightly tender area of the diameter of half a crown; it does not project, and there is no pulsation in it. A very feeble pulse can be felt in the right radial and temporal arteries; it is full and strong in the corresponding vessels of the left side; rate, 76. No pulse is to be felt in the right carotid or brachial arteries. The right arm is not blue, and its nutrition and general appearance are as good as those of the left. The man still complains of pain in the right arm and shoulder, of difficulty in lifting the right arm, and of some tingling down it. These symptoms, however, he is probably making the most of, for he has done no work since the operations, and continues to draw compensation for his "accident." The enlargement of the superficial veins of the right side has disappeared. The man is well nourished, but flabby and of a pallid complexion. His general health is good.

5. ABSTRACTS OF PREVIOUSLY RECORDED CASES, WITH REFERENCES.

1. VALENTINE MOTT, 1818.—M. B., aged fifty-seven years; seaman; admitted to New York Hospital, March 1, 1818. Fall a week previously upon right arm and shoulder, followed by pain and general swelling there. Swelling partly subsided; that left above clavicle at first thought to be inflammatory, but in time developed definite pulsation. Operation, May 11. "Mott's incision," *i.e.*, a transverse incision above the inner part of the clavicle terminating over the trachea, joined to a second incision along the inner edge of the sternomastoid muscle; partial division of the sterno-

mastoid in the line of the transverse wound; transverse division of the right sternolaryngeal muscles.

Subclavian found diseased. Innominate tied with a "round silken" ligature half an inch below the bifurcation. Suppuration. Ligature came away on fourteenth day. Patient up on sixteenth day. Hæmorrhages on ninth and twenty-third to twenty-sixth days. Death on twenty-sixth day. *Necropsy.*—Distal part of innominate with origins of subclavian and carotid ulcerated away. Sac contained coagula, and a carious, disunited clavicle was involved in it. (Mott: *New York Medical Repository*, vol. i, 1818. Velpeau: American Edition by Mott, 1851, vol. ii, p. 206. Poland, vol. xv, p. 76; xvii, pp. 88 and 117 (Case 99).—W. Thomson.)

2. GRAEFE, 1822.—Sailor, aged thirty years; admitted to Berlin University Clinique in autumn of 1821 with a subclavian aneurism of rapid growth. Operation, March 15, 1822. Incision along anterior edge of sternomastoid. Innominate ligatured one inch from aortic arch. Suppuration. Ligature came away on fourteenth day. When wound was nearly healed, repeated hæmorrhages, to which patient succumbed on sixty-seventh day. Fatal result contributed to by suppuration in sac, which was incised. *Necropsy* showed innominate plugged by clot. (Graefe and Walther: *Journal*, 1822, Band iii, Heft 4, p. 599. Ditto, 1825, Band iv, Heft 3, p. 587. *Medical and Physical Journal*, London, 1823, p. 475. Poland, xv, p. 76; xvii, p. 125 (Case 100).—W. Thomson.)

3. GEORGE NORMAN, 1834. Bath.—The only account is that given by Gore in 1878 in the report of his own case (12). "More than fifty years ago a similar operation was performed in this city (Bath), followed by death on the fifth day. But in that instance, although the case was in many respects favorable, the operation was overlong delayed, and was at last undertaken somewhat hastily and unadvisedly owing to the occurrence of a train of symptoms, the true character of which was altogether misunderstood and misinterpreted. They were, in fact, the signs of an attack of acute pericarditis, which was a sufficient cause of death. The state of parts about the seat of ligature as seen after death was very satisfactory and promising, as there was a firm clot on the cardiac side and no signs of suppuration in the mediastinum."

Mr. C. Noel Davis, House Surgeon, Royal United Hospital, Bath, has very kindly searched the hospital records for me, but has been unable to find any notes of this case. The specimen is in the hospital museum. The catalogue notes state that the case was one of aneurism of the right subclavian in a male patient. (Gore: *Lancet*, London, 1878, vol. ii, p. 119. Poland, xv, pp. 76 and 126 (Case 101). Ferguson's Surgery, Philadelphia, 1845, p. 429. Erichsen's Surgery, fourth edition, p. 645.)

4. ARENDT, 1827.—J. L., countryman; aged thirty-six years; admitted to Iwanhoff Hospital, St. Petersburg, December 3, 1827. Blow on right shoulder a year previously, followed by swelling, which subsided, to reappear six weeks before admission. Subclavian aneurism. Operation on or about December 24. Incision along inner edge of sternomastoid; innominate ligatured. Suppuration. Death on eighth day from "exhaustion." *Necropsy.*—Puriform infiltration of parts. Inflammation of right lung.

Ligature had cut through inner coats of innominate. Sac contained grumous blood and fibrous lamellæ. Effused lymph on brain. Liver large and soft. (Dietrich's Collection, p. 188. Poland, xv, p. 76; xvii, p. 126 (Case 102).)

5. J. HALL, 1830.—H. J., aged fifty-two years; laborer; admitted to Baltimore Hospital, 1830. Tumor above right clavicle since "first months" of 1830. Aneurism of subclavian. Ligature of innominate, September 7; artery diseased with adhesions round it; bleeding followed separation of adhesions, requiring compression. Artery tied; bleeding recurred; wound plugged and operation terminated. On September 10 patient got up and walked about. Bleeding from wound, September 11. Death, September 12, fifth day from operation. *Necropsy.*—Wound fœtid. Ligature had been carried through the coats of the innominate, making two holes. Dense clot in sac. (*Baltimore Medical and Surgical Journal and Review*, 1833, vol. i, p. 125. Poland, xv, p. 76; xvii, p. 127 (Case 103).—W. Thomson.)

6. W. BLAND, 1832.—J. M.; male; aged thirty-one years; admitted to Benevolent Asylum, Sydney, New South Wales, March, 1832. Throbbing tumor above right clavicle for two years. Ligature of innominate, March 26, 1832. Incision in direction of fibres of right sternolaryngeal muscles, with separation of their fibres; also division of sternal head of sternomastoid. Ligature, "consisting of two threads," tied so as to divide inner coats. Patient got up April 1. Discharge from wound "creamy." Hæmorrhage, seventeenth and eighteenth days. Death eighteenth day. *Necropsy.*—Innominate and carotid plugged with clot. Innominate nearly divided by ligature which remained around vessel. Hæmorrhage from subclavian distal to ligature.

In his remarks upon the case (in the postoperative treatment of which there were numerous venesections), Bland regrets that he did not bleed with a more *liberal hand.* (*Lancet*, London, vol. i, 1832–1833, October 20, p. 97. Poland, xv, p. 76; xvii, p. 128 (Case 104).—W. Thomson.)

7. BUJALSKY, 1833.—W. M.; male; aged fifty-six years. Patient in Military Hospital, St. Petersburg. Aneurism of right subclavian. Tumor large, extending from armpit to edge of inferior maxilla; apex covered by red skin; clavicle divided into two parts. Ligature of innominate, March 11, 1833. Vessel tied after the rules laid down by Bujalsky in "Tabulæ Anat.-Chirurg.," the artery being tied by means of a "tourniquet" (und unterband die arterie anonyma mittels des von mir erfundenen tourniquet). Incision extended almost to inner margin of sternomastoid. Operation difficult owing to scars in the neck from old scrofulous glands. Subsequently shivering, heat, and rapid pulse. Death on March 16, fifth day after operation. *Necropsy.*—Aneurismal dilatation of heart, aorta, and arch of aorta. Pus in pericardium and left pleura. (Kriegs Medicinische Zeitung, 1833. "Tabulæ Anatomico-Chirurgicæ Ligandarum Arteriarum Majorum Exponentes," St. Petersburg. Elephant Folio, 32 pp., 14 plates. Reference in Medical and Surgical History of the War of the (American) Rebellion. Surgical volume, part i, p. 537. Thèse Inaugurale de M. Beistigni, Paris, 1841 (communication from Velpeau). Poland, xvii, pp. 88 and 92.—W. Thomson.)

8. BUJALSKY, 1833 ? (second case).—Subclavian aneurism probably. No details obtainable. Death shortly after operation. (References as under 7.)

9. A PARIS SURGEON, 1834.—Case mentioned by Dupuytren. Hæmorrhage. Death on third day. (Dupuytren: Leçons Orales de Clinique Chirurgicale, p. 611, Paris, 1834.—W. Thomson. Poland, xv, p. 78; xvii, p. 88 (Case 106).—Souchon.)

10. LIZARS, 1837.—Case first described in the "Caledonian Mercury" of June 1, 1837, by an enterprising reporter, who was attracted by the crowd entering the Royal Infirmary to witness the operation. A. D.; aged thirty years; carter; admitted to Royal Infirmary, Edinburgh, May 28, 1837. Subclavian aneurism, size of small egg. Falls on right shoulder, fifteen and eleven months previously; on second occasion fracturing clavicle; cramps and tingling in right arm, six to seven weeks. Innominate ligatured May 31; incision along inner border of sternomastoid; right sternolaryngeal muscles cut across; both ends of ligature cut short. Pulsation returned in aneurism, but disappeared in twenty-four hours; wound suppurated; knot of ligature came away seventeenth day; hæmorrhages; death, twenty-first day. *Necropsy.*—Hæmorrhage into right side of thorax. Innominate "separated" near ligature at seat of hæmorrhage. Sac of aneurism collapsed and full of coagula. (*Lancet*, London, 1837, vol. ii, pp. 441, 445, 602. Poland, xv, p. 78; xvii, p. 132 (Case 105).)

11. HUTIN (Paris), 1842.—N. C., aged twenty-seven years; soldier; fighting a duel at Oran, wounded in right axilla by scissor-blade tied to end of a stick. Hæmorrhage; arrested by plugging wound, but recurred fourth to twelfth days. Third part of subclavian tied on twelfth day. Eighteenth day, hæmorrhage from axilla. Twenty-first day, subclavian ligature came away, followed by further hæmorrhage; innominate artery tied at midnight; flat ligature with an additional "ligature of reserve." Patient died eleven hours later. *Necropsy.*—Ligature had been properly applied. Original hæmorrhage from inferior thoracic branch of axillary. (*Lancet*, London, 1841–1842, vol. ii, p. 230.—W. Thomson. Archives de Chirurgie Française et Étrangère. Poland, xvii, p. 137.)

12. R. T. GORE, 1856.—D. D.; male; aged fifty-two years; baker; admitted to Bath United Hospital, September 22, 1856. Aneurism in axilla and root of neck of three years' duration; more prominent when patient lies down. Innominate tied under chloroform, September 24. Mott's incision; hempen ligature used. Slight erysipelas, fifth day; phlebitis right arm and left leg, eleventh day; suppuration; rigors; cough; arterial hæmorrhage on October 10 (seventeenth day), causing death in an hour. *Necropsy.*—Innominate partly cut through by ligature. Innominate and carotid plugged by clot. Aneurism filled with a firm coagulum. Pus in anterior mediastinum. (*Lancet*, July 27, 1878. Poland, xv, p. 78; xvii, p. 136 (Case 109).)

13. PIROGOFF, St. Petersburg, 1856.—Male; aged forty-six years. Right subclavian aneurism, occupying the site of an old abscess. Ligature of the innominate. Cough; râles in chest; paralysis of left side of face; death in forty-eight hours. *Necropsy.*—Acute inflammation of arterial

sheath and around ligature; pleurisy; purulent mediastinitis; œdema of lungs; pneumonia; extravasated blood over both hemispheres. (Allgemein Kriegs Chirug., 1864, p. 459. Poland, xv, p. 78; xvii, p. 137 (Case 110).)

14. Cooper, San Francisco, 1859.—Male patient. Two aneurisms, one at root of subclavian, the other at root of carotid, united by adhesions. Incision, Mott's modified, with removal of summit of sternum and sternal end of clavicle. Innominate dilated by aneurism and ligatured within three-quarters of an inch of the aorta. After five days, restlessness, dyspnœa, retention of urine. Death on ninth day. *Necropsy.*—Pus in right kidney; no mention of condition of aneurism or of seat of ligature. (*American Journal of the Medical Sciences*, N. S., vol. xxxviii, 1859, p. 395. Poland, xv, p. 78; xvii, p. 135 (Case 107).—W. Thomson.)

15. Cooper, San Francisco, 1860 (second case).—Disease not stated; probably aneurism. Upper part of sternum and sternal end of clavicle removed. Ligature of innominate. Hæmorrhages, arrested by compression. Patient removed the bandages and allowed himself to bleed to death on the thirty-fourth day. Hæmorrhage believed to be from distal end. (*San Francisco Medical Press*, January, 1861. Gaz. Hebdom., 1861, p. 612. Poland, xv, p. 78; xvii, p. 135 (Case 108).—W. Thomson; W. G. Spencer.)

16. A. W. Smyth, 1864.—W. M.; mulatto; aged thirty-three years; steamboat steward; admitted at New Orleans Hospital, May 9, 1864. Aneurism of right subclavian dated from a collision of patient's ship in February, 1864, when he hung from an anchor with another man clinging to him. Small throbbing tumor noticed a month later, which gradually enlarged. Operation, May 15. Mott's incision. Ligature of the innominate quarter of an inch from the bifurcation and of the carotid. Ligature came away from carotid on May 28 and from innominate on June 2. Hæmorrhages on May 29, 30, and 31; lint packing. Wound filled with small shot on June 1. Some shot removed June 17, return of hæmorrhage. Further hæmorrhages, and on July 5 "terrific hæmorrhage," which ceased spontaneously. July 9, ligature of vertebral; all shot removed following day; complete recovery. May, 1869, no vestige of aneurism. June, 1874, aneurism recurred and became larger than at first. October 5, internal mammary tied; some improvement (?). Abscess above clavicle opened March 29, 1875; two days later aneurism ruptured into cavity of abscess; sac laid open and stuffed with lint; mouth of supplying vessel not found. Death, April 6, 1875. *Necropsy.*—(Arteries injected.) Innominate had been tied less than an inch from its origin; fibrous tissue beyond. Carotid occluded to its bifurcation and subclavian to within quarter of an inch of thyroid axis, which, with its branches, was pervious. Vertebral occluded to fourth cervical vertebra. (*American Medical Times*, vol. ix, 1864, p. 95, August 20. *American Journal of the Medical Sciences*, N. S., vol. lii, 1866, p. 280. Sydenham Society's Biennial Retrospect, 1865–6, p. 646. Smyth: Report of the Successful Ligature of the Innominate, the Common Carotid, the Vertebral and the Internal Mammary Arteries, New Orleans, 1876.—W. Thomson. *Dublin Jour. Med. Sci.*, 1876, third series, vol. lxii, p. 482. Poland, xv, p. 78; xvii, p. 141 (Case 111).—Souchon.)

17. Lynch, New York, 1867.—Gunshot wound of the internal carotid and vertebral arteries. Ligature of the innominate for secondary hæmorrhage, the common carotid having been tied a month previously. Hæmorrhage on twelfth day and the patient died soon after. *Necropsy.*—Partially organized clots in cardiac end of innominate. (*Medical Gazette*, New York, 1868, vol. i, p. 100.—W. Thomson.)

18. E. R. Bickersteth, 1868.—J. J.; aged forty years; dock porter; admitted to Liverpool Royal Infirmary, April 15, 1868. Subclavian aneurism size of a hen's egg, attributed to a strain in lifting three weeks previously. Operation, May 5. Mott's incision; specially made lead wire clamp, with screw for tightening, applied round the innominate. On May 7 pulsation returned in the aneurism and the lead wire was found to be broken. Clamp removed and vessel tied with silk above and below where the wire had been. Suppuration. Hæmorrhage from the wound, May 13 and 14. Shot poured into wound. Death, May 14, seventh day after ligature. *Necropsy.*—Clot in aneurism and in innominate from aorta to point of ligature. Hæmorrhage from "the distal side of the upper" ligature. (*Medico-Chirurgical Transactions*, vol. lvi, 1873, p. 129. *Lancet*, London, December 7, 1872, p. 815.)

19. A. B. Mott, New York, 1868.—Male patient. Subclavian aneurism. Operation, August 13, 1868. Innominate and carotid tied. Ligature came away on twentieth day; hæmorrhages; death on twenty-third day. *Necropsy.*—Hæmothorax; sac ruptured into pleural cavity. (Wyeth: *Trans. Amer. Med. Association*, vol. xxix, 1878, p. 168.—W. G. Spencer.)

20. S. B. Partridge, 1870.—R. C.; a native hawker; admitted to Medical College Hospital, Calcutta, April 17, 1870. Aneurism of right carotid of one and a half years' duration. Common carotid tied below omohyoid. Ligature separated on May 2, thirteen days after operation; on same day patient feverish and coughing, and at 10 P.M. sudden gush of arterial blood from wound; innominate ligatured just below bifurcation; patient died one and a half hours later. (*Indian Annals of Medical Science*, vol. xiv, p. 222.—W. Thomson.)

21.—E. S. O'Grady, Dublin, 1873.—Patient, a cabinet-maker; work entailed considerable strain on right shoulder. Large aneurism of three years' duration in axilla and above clavicle. Operation, inner two inches of clavicle removed; carotid and innominate tied. Death in twenty hours. *Necropsy.*—Serous effusion into cerebral ventricles. (Power: Anatomy of the Arteries, third edition, by W. Thomson, p. 49.—W. Thomson.)

22. G. Buchanan, 1880.—T. W., aged forty years; stone-dresser; admitted to Western Infirmary, Glasgow, April 19, 1880. Tumor right side of neck for four months; large subclavian aneurism with inflamed skin over it. Potassium iodide and morphia given May 14; galvanopuncture. Subsequently, repeated bleedings from needle punctures and great increase in size of tumor, so that it pressed on larynx and trachea. June 1, sharp hæmorrhage and large clot noted, forming a projection covered by thin skin which had given way in two places. Bleeding stopped spontaneously. Operation same day; incision in line of carotid and transversely across tumor; gush of arterial blood stopped by pressure.

Sac had burst before operation; rent found in vessel at bifurcation of innominate; innominate ligatured. Patient died in a few minutes. (*Glasgow Medical Journal*, fourth series, vol. xiv, 1880, p. 152.)

23. W. THOMSON, 1882.—J. M., aged forty-nine years; locksmith; admitted to Richmond Surgical Hospital, Dublin, February 7, 1882. Never had syphilis; fairly temperate; had fought in the American Civil War. Pains in right arm two and a half years; tumor in neck two months; aneurism of second and third parts of subclavian. Left hospital. Readmitted, May 22. Operation, June 9. Mott's incision; innominate tied with flat (ox aorta) ligature, secured with three knots, drawn with moderate firmness. After-progress at first good. Drainage-tube removed on the seventh day, and a few strands of catgut substituted for it. Suppuration; hæmorrhage on thirtieth and thirty-ninth days; death on forty-second day. *Necropsy.*—Drainage-tube sinus had become septic, producing ulceration on anterior face of innominate distal to ligature; from this place hæmorrhage had apparently taken place. Aneurism full of clot; inner coats of innominate not divided, and vessel not occluded, a "chink" remaining; no trace of ligature. (*Brit. Med. Jour.*, 1882, vol. ii, p. 722. International Encyclopædia of Surgery, vol. iii, p. 538.—W. Thomson.)

24. W. M. BANKS, 1883.—J. B., aged fifty years; male; admitted to Liverpool Royal Infirmary, February 10, 1883. Aneurism of third part of subclavian. Rest, etc., tried without good effect, and on February 26 innominate and carotid tied through Mott's incision; kangaroo tendon ligatures used, and tied with a force thought sufficient to occlude artery without damaging coats. Pulsation in aneurism returned same evening, and remained. Wound healed and patient went out on twentieth day. Readmitted, and sixty-seven days after first operation first part of subclavian tied with great difficulty, a double catgut ligature being used. Sepsis; bronchopneumonia; hæmorrhage from wound thirty-first and following days; patient died thirty-seventh day. On fourth day, aneurism small, hard, and free from pulsation. *Necropsy.*—Innominate patent. (Jacobson: *Brit. Med. Jour.*, 1885, vol. i, p. 230. Proc. Royal Medico-Chirurgical Society, N. S., vol. i, p. 232.—W. G. Spencer.)

25. BULL, New York, 1884.—Subclavian aneurism. Innominate, carotid, and vertebral simultaneously ligatured with double catgut ligatures. Death on thirty-third day from hæmorrhage.—(Burrell.)

26. BENNETT MAY, 1886.—J. N., aged thirty years; brewer's laborer; admitted to Queen's Hospital, Birmingham, March 3, 1886. For years great exertions and violent straining, particularly of right shoulder, which has been dislocated three times. No syphilis. Moderate drinker. Shooting-pains and numbness down the arm for seventeen months; swelling above clavicle nine weeks. Aneurism of subclavian extending under sternomastoid. Rest, Tufnell's diet, and potassium iodide. No improvement, and patient not willing to continue the treatment. Operation, March 27. Innominate tied through Mott's incision; ox aorta ligature broke, so five or six strands of medium-sized catgut used and tied as one ligature, secured with three knots; endeavor made to avoid crushing coats of artery; wound drained. Pulsation returned in aneurism the following

day; hæmorrhage from wound, April 10 and following days; suppuration; death, April 14, eighteen days after the operation. *Necropsy.*—Large aneurism, which had eroded vertebræ, and occupied all three stages of the subclavian artery. Knot of ligature very large and hard, and under it a hole in the artery, from which the hæmorrhage had taken place; inner coats otherwise intact. (*Lancet*, London, 1886, vol. i, p. 1064.)

27. DURANTE, 1887.—G. S.; employé; aged forty-five years; admitted to Durante's Clinique, Rome, March 20, 1887. Tingling and pain in arm for two years. Tumor above clavicle one month. Aneurism between scaleni. Operation, March 25. Ligature of innominate, carotid, and vertebral through Mott's incision. Drainage-tube left in until April 3. Sepsis; right hemiplegia; hæmorrhages commencing April 6; death fifteenth day (April 9). *Necropsy.*—Aneurism collapsed and containing coagula; embolic softening of left caudate nucleus. (W. G. Spencer: *Lancet*, London, April 30, 1887, p. 876. Sajous: *Journal*, 1888, p. 251.—Souchon.)

28. J. LEWTAS, 1889.—Patient, a soldier, aged twenty years, in Murdan Hospital, Punjaub, India. A month before operation his gun burst, and he thought that a piece of the breech lodged above the right collar-bone; bleeding from the wound there for three days before admission. Hard, non-pulsating swelling above clavicle, with brownish blood oozing from partly healed wound in its centre; thought to be an abscess. Operation, May 13. Wound enlarged and fragment of steel removed; profuse hæmorrhage, stopped by pressure; incision along inner margin of sterno-mastoid; innominate and carotid tied with catgut. Recovery. The operator remarks that, had he known how unfavorable the results of operation were, he would have contented himself with plugging the wound. (*Brit. Med. Jour.*, 1889, vol. ii, p. 312.)

29. G. E. TWYNAM, 1889.—E. P.; female; aged eighteen years; admitted to Prince Alfred Hospital, Sydney, New South Wales, having one month previously (on July 21, 1889) been thrown from a horse, fracturing the right clavicle and bruising the right shoulder. Boggy swelling formed above clavicle, which increased in size; pulsation; much pain. Operation. Central incision and separation of sternolaryngeal muscles; innominate and carotid tied with silk; wound closed without drainage. Following morning, about 9 A.M., patient suddenly became unconscious with left facial paralysis, and died in an hour. *Necropsy.*—Wound only examined. Sac contained coagula and communicated with first part of subclavian by a rounded aperture; inner coat of innominate completely ruptured by ligature; no distal plug of blood-clot in innominate or carotid. Cause of death uncertain, as brain was not examined. Twynam suggests thrombosis of cerebral veins. (*Lancet*, London, 1890, vol. i, p. 1352.)

30. W. H. A. JACOBSON, 1890.—A. H.; gamekeeper; aged forty-eight years; admitted to Guy's Hospital, London, February 10, 1890. Large aneurism in axilla and above clavicle. Swelling noticed a year before. Ligature of the innominate and carotid through Mott's incision, with removal of the inner end of the clavicle; ox aorta used for ligature material, and tied so as to close vessel without injuring coats; drainage-tube inserted. Pulsation ceased in aneurism and never returned. Rest-

lessness, delirium, and bronchopneumonia; died, exhausted, on tenth day after operation. *Necropsy.*—Large aneurism of second and third parts of subclavian, filled with clot; remains of ligature loose, round innominate, but no knot found; drachm of "quite sweet puslike fluid" surrounding bifurcation of innominate; bronchopneumonia of both bases; valvular disease of heart; atheroma of aorta; early nephritis. Brain normal. (Jacobson.)

31. C. COPPINGER, 1893.—Man; aged fifty-three years; admitted to Mater Misericordiæ Hospital, Dublin, December 5, 1892, with aneurism of the second and third parts of the subclavian and aneurismal dilatation of the axillary artery. Operation, January 9, 1893. Ligature of innominate and carotid through Mott's incision; silk used; carotid tied in two places and divided; strict antiseptic precautions. On third day, when dressings were removed, no pulsation in aneurism. Patient shown at meeting of British Medical Association at Newcastle-on-Tyne in August, 1893; good health; strong and useful right arm; no pulse at right wrist; small, hard swelling above clavicle. On July 4, 1895, patient was seen at St. Bartholomew's Hospital, London, and was then quite free from any trace of his aneurism. (Letter from Dr. Alfred Willett to Dr. Coppinger.) (*Lancet*, London, vol. ii, 1893, p. 327. Trans. Roy. Acad. Med., Ireland, vol. xi, 1893, p. 243. *New York Medical Journal*, April 8, 1893.—Souchon.)

32. C. J. SYMONDS, 1894.—G. M.; aged fifty-three years; male; admitted to Guy's Hospital, London, October, 1894, with subclavio-axillary aneurism. Operation, November 5, 1894. Attempt first made to ligature first part of the subclavian through a vertical incision over the sternomastoid, but sharp hæmorrhage occurred on attempting to pass the needle round the artery; thought that some branch of thyroid axis was injured. Mesial vertical incision made and the two vertical incisions joined by a transverse one above the clavicle, the sternal head of the sternomastoid being divided; innominate and carotid tied with silk. Two sinuses formed after operation, through which catgut and one piece of silk came away. Patient seen in June, 1895; aneurism hard; usefulness of limb returning; no pulse in radial; pulse in carotid above ligature. In response to an inquiry, Mr. Symonds kindly writes on October 1, 1904, "The man died some time ago of a general malady."—(Jacobson.)

33. H. L. BURRELL, 1895.—R. F.; male; aged fifty-four years; a clerk; patient in Boston City Hospital. "Lump in throat" for eighteen months. Pulsation in vessels of right side of neck with expansive thrill and bruit; undue pulsation in various other arteries; heart systolic and diastolic murmurs. Operation, January 15, 1895. Ether. Mott's incision, with removal of sternoclavicular articulation and adjacent portion of sternum; innominate found much dilated (estimated diameter one and one-quarter inches); ligatured with flat, braided-silk tied in a "square (reef) knot;" knot tied slowly; coats of the vessel felt to give way; second similar ligature placed half an inch distally to the first (first ligature to act as "breakwater"); wound closed without drainage. Primary wound healing; pulsation ceased in aneurism; pulse returned in radial but not in carotid; patient got up on the fifty-ninth and left hospital on

the seventy-third day. Subsequently, œdema of feet and heart trouble. Died suddenly from heart failure on the one hundred and fourth day after operation. *Necropsy.*—Hypertrophied and dilated heart; chronic congestion of lungs, liver, spleen, and kidneys; old pleurisy; ascites; general arteriosclerosis; circumscribed dilatation (fusiform aneurism) of right subclavian, of innominate and of right iliac; innominate had been occluded by distal and severed by promimal ligature, the latter ligature being found inside the artery, the lumen of which had been restored; chronic interstitial orchitis (indicating syphilis).—(Burrell.)

34. B. FARQUHAR CURTIS, 1899.—M. A.; aged fifty-three years; carpenter; admitted to St. Luke's Hospital, New York, November, 1899, with subclavio-axillary aneurism. Symptoms of some months' duration. Rest, limited diet, and potassium iodide improved the condition of the arteries and moderated the heart's action. Ligature of the innominate, December 2, 1899. Median incision; separation of sternolaryngeal muscles; splitting of manubrium sterni in middle line; transverse division of sternum above second rib. Innominate much dilated, but with apparently healthy walls; ligatured with a double heavy chromicized catgut ligature, the two threads being tied simultaneously; internal coats not divided; single similar ligature put round vessel a quarter of an inch distally to the first; wound closed with gauze drainage. Some sepsis and slow wound healing; no hæmorrhage; pulsation returned in the aneurism four days after the operation.

March 13, 1900. Second operation. Carotid and first part of subclavian tied, the clavicle being divided and wired. Innominate impervious; pulsation in sac came from some branch of first part of subclavian. Some sepsis followed, attributed to difficulty in sterilizing rough and wrinkled skin of patient. On October 24, 1900, patient in good health, with no trace of the aneurism. Dr. Curtis kindly writes that "patient was kept under observation for eleven months, when he was well and apparently cured of his aneurism."—(ANNALS OF SURGERY, October, 1901.)

35. C. A. BALLANCE, 1902.—Patient, a royal marine; aged thirty-five years; admitted to St. Thomas's Hospital, London, March 27, 1902. Exposed to syphilitic infection and had gonorrhœa in 1885. Pain in neck and cough for six months; swelling in neck for three months. Treated for a period before admission by rest, reduced food and drink, and large doses of potassium iodide; but swelling continued to increase in size. Large aneurism involving innominate and origins of carotid and subclavian; dulness under right upper part of manubrium. Operation, April 15, 1902. Median incision; separation of sternolaryngeal muscles; manubrium bisected vertically; horizontal division of sternum at level of second costal cartilages; half an inch of bone removed on each side of vertical bone incision; about half an inch of undilated innominate found between aneurism and aorta; vessel tied in a "stay knot" with four strands of No. 4 goldbeaters' skin; carotid also tied. Patient developed left hemiplegia on the afternoon of the day of operation, and died in the evening. *Necropsy.*—Thrombosis of right middle cerebral artery; aneurism of innominate, origin of carotid, and first and second parts of subclavian;

ligature held walls of innominate in contact without rupture of coats. The author thought that the cerebral thrombosis was contributed to by the debilitated condition produced by the Valsalvan treatment. (*Lancet*, London, 1902, vol. ii, November 1, p. 1180.)

CASES OF ATTEMPTED LIGATURE, ETC.

1. W. H. PORTER, Dublin, 1832.—Male; aged forty-seven years; laborer. Very large subclavian aneurism of two and one-half years' duration. Attempt to find a healthy portion of innominate failed; operation abandoned; wound suppurated. Subsequently, pulsation diminished, and finally ceased in tumor. Porter, seven years later, wrote that the tumor had entirely disappeared, and he believed the patient to be alive and well. (*Dublin Journal*, 1832, vol. i, p. 25. Poland, xv, p. 66; xvi, p. 68; xvii, p. 99 (Case 62).)

2. HOFFMAN, New York, 1839. (Case also described by Post.)—Negro; aged sixty-three years. Aneurism of subclavian of five months' duration. Operation, October 26, 1839. Innominate too diseased for application of ligature. Death from exhaustion three months later. *Necropsy.*—Atheroma of aorta and innominate; two aneurismal sacs on subclavian artery. (Catalogue of Pathological Cabinet, New York Hospital Museum, p. 288 (or 258?). (Prep. 630.) Poland, xv, p. 68; xvi, p. 71 (Case 64). Gross: Surgery. *New York Journal of Medicine*, No. 4, p. 370. (Post.))

3. ASTON KEY, 1844.—Married woman; aged forty-six years; admitted to Guy's Hospital, London, April 25, 1844. Aneurism of right subclavian of three months' duration. Attempt to tie innominate failed. Hæmorrhage from wound on seventh day. Sac enlarged, pressing on trachea. Death from dyspnœa, twenty-fifth day. *Necropsy.*—Atheroma of aorta; small aneurism of descending thoracic aorta; aneurisms of innominate and subclavian, vessel remaining of its normal caliber between the scaleni; death apparently from pressure on trachea. (Crisp, p. 206. Poland, xv, p. 66; xvi, p. 70 (Case 63).)

4. ANTONIO JOSÉ PEIXOTO, 1851.—Patient, Dr. J. A. de Moura, a Portuguese; aged thirty-three years. In 1832 developed vascular tumor of right ear, which increased in size. "Bleeder" symptoms. Posterior auricular artery tied by Nélaton in 1845. On November 14, 1851, common carotid tied in Rio Janeiro; hæmorrhage from wound on December 4 and 7; "*ligature d'attente*" passed under innominate on December 8; no further bleeding, so the ligature was withdrawn on December 13, without being tied. Cure complete in two months. (Poland, xvii, pp. 89 and 92. W. Thomson. Koch (Case 129). Mémoires de l'Académie Impériale de Médicine, vol. xix, 1855, p. 23. *Amer. Med. Jour.*, January, 1857, vol. xxxiii, p. 255. *British and Foreign Med. Review*, October, 1856, vol. xviii, p. 353.)

5. G. H. PORTER, 1867.—P. G.; aged forty-three years; laborer; admitted to Meath Hospital, Ireland, June 11, 1867. Aneurism of subclavian of fourteen months' duration. June 26, acupressure of axillary continued for fifty-three hours; no permanent improvement. July 31, innominate

CASES OF ATTEMPTED LIGATURE, ETC.

No.	Operator.	Place and Date of Operation.	Sex and Age of Patient.	Disease and its Duration.	Procedure.	Result.
1	W. H. Porter.	Dublin, 1832.	Male, 47.	Subclavian aneurism; 2½ years.	Attempted ligature.	Innominate unhealthy; sepsis; recovery.
2	Hoffman.	New York, 1839.	Male, 63.	Subclavian aneurism; 5 months.	Attempted ligature.	Innominate unhealthy; death 3 months later.
3	Aston Key.	Guy's Hospital, London, 1844.	Female, 46.	Subclavian aneurism; 3 months.	Attempted ligature.	Sac large; hæmorrhage; death, 25th day.
4	Antonio José Peixoto.	Rio Janeiro, December 8, 1851.	Male, 33.	Vascular tumor of ear; 19 years.	Ligature passed but not tied.	Recovery.
5	G. H. Porter.	Meath Hospital, Ireland, July 31, 1867.	Male, 43.	Subclavian aneurism; 14 months.	Clamp used.	Death, 10th day; sepsis; hæmorrhage.
6	T. Annandale.	Royal Infirmary, Edinburgh, May 27, 1885.	Male, 53.	Subclavian aneurism; 13 months.	Clamp used.	Death, 12th day; sepsis; hæmorrhage.
7	Communicated by E. Souchon.	Charity Hospital, New Orleans, 1894.	.....	.....	Attempted ligature.	Innominate unhealthy.

laid bare and compressed between the blades of an instrument something like a lithotrite, one blade being passed under the artery and the other made to slide down on it. Pulsation ceased, but returned next day; instrument screwed tighter, but pulsation only temporarily arrested; removed next day (August 2). Hæmorrhage from wound on August 9 and 10. Death, August 10 (tenth day). *Necropsy.*—Sloughy aperture on anterior surface of innominate just below bifurcation; artery had evidently partly slipped from between blades of compressor, which were too short. (*Dublin Quarterly Jour. of Med. Sciences*, vol. xliv, November, 1867. Poland, xvi, p. 63; xvii, p. 101 (Case 55). *Medical Press and Circular*, Dublin, 1877, pp. 8 and 131.—W. Thomson.)

6. T. ANNANDALE, 1885.—J. B.; male; aged fifty-three years; admitted to Royal Infirmary, Edinburgh, May 14, 1885. Aneurism of second and third parts of subclavian of thirteen months' duration. Had been treated in the Infirmary about a year previously by rest, dieting, and potassium iodide without any effect on aneurism. Aneurism attributed to a strain. No history of syphilis. Operation, May 27. Innominate exposed through a "median cervical incision;" specially designed compressor applied to artery and found to be efficient in stopping the circulation; compressor removed and piece of half-inch india-rubber drainage-tube adjusted, so that one end of it lay behind the artery while the other protruded from the external wound. (The idea was subsequently to use the compressor, slipping its small blade into the drainage-tube.) Wound healed except where drainage-tube was inserted. Hæmorrhage from wound on eleventh and twelfth days; attempt to ligature innominate on latter day failed, so the compressor was applied, stopping the bleeding. Death five hours later. (*Lancet*, London, vol. i, 1886, March 13, p. 481.)

7. E. SOUCHON, 1894.—In a personal letter to Burrell, Souchon speaks of a case in the Charity Hospital, New Orleans, in which the innominate was exposed by removal of part of the sternum, but not ligatured, because it was found so greatly enlarged.—(Burrell.)

6. *Commentary.*—The number of cases in which the innominate has been approached by operation with a view to its obliteration is 43. In 36 of these ligature was accomplished, 28 dying, 8 recovering, a mortality of 78 per cent. Subtracting the cases in which the patients were moribund at the time of operation or died a few minutes after operation, viz., Hutin's (11), Partridge's (20), Buchanan's (22), and probably also Bujalsky's second case (8), 32 cases are left with 24 deaths, a mortality of 75 per cent. Omitting all cases prior to 1871, *i.e.*, prior to the antiseptic period, a total of 16 cases is left (O'Grady's to Sheen's) with 9 deaths, a mortality of 56, 25 per cent. Of the last six cases operated on, five recovered.

Fatal Cases. (1) *Sepsis and Hæmorrhage.*—Thirteen out of the 24 deaths were certainly due to suppuration in the wound causing secondary hæmorrhage. (Cases 1, 2, 6, 12, 15, 17, 18, 19, 23, 25, 26, 27). Two other cases died of hæmorrhage; in one (Hutin, 11) there was direct injury to the artery; in the other (Dupuytren, 9) the cause is not stated. Hæmorrhage commenced as early as the third day (9) and as late as the thirtieth day (23) after the operation. Hæmorrhage having supervened, death usually occurred in from a few hours to three or four days. In Gore's case (12) the hæmorrhage was so furious that death resulted within an hour of its appearance, while in Thomson's case (23) life was prolonged to 12, and in V. Mott's case (1) to 17 days after the appearance of the hæmorrhage. In some cases hæmorrhage commenced at the time of extrusion of the ligature, in others not until some days afterwards. Death occurred as early as the third day (Dupuytren, 9) and as late as the sixty-seventh day (Graefe, 2) after the operation. The latter case teaches us that the risk of hæmorrhage does not cease for a long time, and is present at least as long as there is any discharge from the wound. In two cases (Thomson, 23; Durante, 27), probably in others, sepsis and hæmorrhage were contributed to by the use of a drainage-tube. Bennett May attributes the hæmorrhage in his case (26) to the large hard knot eroding the artery. Hall's (5) is an isolated case. In Jacobson's case (30) the "drachm of sweet pus-like fluid" round the innominate bifurcation suggests the possibility of sepsis and hæmorrhage had the patient survived. In almost all these cases there was an ulcerative arteritis at the site of ligature leading to perforation. In one or two the perforation seems to have been produced adjacent to the deep end of a drainage-tube.

(2) *Sepsis.*—This alone caused death in three cases. (Arendt, 4; Bujalsky, 7; Pirogoff, 13). In all besides the local inflammation there was apparently a condition of acute septic intoxication, and death occurred early, in from two to eight days.

(3) *Cerebral Lesions.*—Three deaths were due to this

cause, the exact lesions being various. (O'Grady, 21; Twynam, 29; Ballance, 35.) In several other cases cerebral symptoms were present, and in two (Pirogoff, 13; Durante, 27) cerebral lesions were found after death.

(4) *Other Causes of Death.*—There remain only three cases to put under this heading: Norman's (3), acute pericarditis; Cooper's first case (14), pus in right kidney, both scantily recorded, and Jacobson's case, bronchopneumonia and acute mental disturbance resembling delirium tremens.

Cases of Recovery.—These are eight in number. Only one (Smyth's, 16) belongs to the preantiseptic period, being the only case which survived the great danger of secondary hæmorrhage. Smyth's and Banks's (24) cases both died of conditions connected with the aneurism, the former 11 years and the latter 104 days after the ligature of the innominate. Burrell's case (33) never completely recovered, and died on the 104th day of general arterial and visceral disease. Symonds's case died of causes unconnected with the aneurism. The cases of Lewtas (28), Coppinger (31), Curtis (34), and Sheen (36) were alive and well when last heard of. Coppinger's case is known to have survived the operation two years, Curtis's 11 months, and Sheen's 8½ months. Omitting Burrell's case, in four of the remaining seven secondary ligaturing operations were required. In only three did the one operation bring about permanent consolidation in the aneurism, the innominate and carotid being simultaneously ligatured in each of the three.

Cases in which the Innominate was cut down upon but not ligatured.—These require little comment. A clamp may slip, may injure the artery, and, by necessitating an open wound, is likely to bring about infection. The spontaneous recovery in W. H. Porter's case (1) after suppuration is interesting.

Asepsis.—To induce and maintain asepsis is imperative in ligature of the innominate. This should be easy under modern conditions, but one or two special precautions are necessary. The preparation of the patient's skin should be com-

menced at least two days before the operation, or even longer when the skin is rough and wrinkled (*cf.* Curtis's case), the superficial epithelium being removed by hot boracic fomentations. The anæsthetist should be screened off by a sterile linen sheet after the plan so successful in Kocher's hands in cases of goitre.* The sterilized cloths should be stitched to the skin close round the wound to prevent their displacement. A drainage-tube should not be used.

Cerebral Lesions.—At the present time, asepsis being attainable, a study of the cases shows that a fatal result is most to be feared from cerebral complications. To lessen this possibility, I suggest that the operation should be performed in two stages, the carotid being tied about a fortnight before the innominate. The central incision could be used for both operations.

General and Local Conditions as Factors determining Success.—Marked general arterial disease with accompa visceral changes is unfavorable; a circumscribed aneurism with good general condition is favorable. Burrell's (33), although in the list of successes, is a typically unfavorable case: the aneurism was less an aneurism than part of a general arterial dilatation, and all the viscera were extensively diseased. In this case the ligature of the innominate being aseptically conducted did not do any harm, but it probably did little good. The innominate at the point of ligature was one and a quarter inches in diameter, or about the diameter of the normal aorta at its origin; whereas, the normal diameter of the innominate is just over half an inch. The ligature then was really put round the aneurism, if one can apply the term aneurism to a general dilatation of the innominate and subclavian. If circumscribed, the actual size of the aneurism does not matter, as shown by Ballance's case, where the sac reached to within half an inch of the aorta.

Ligature on Failure of Lesser Operative Measures.—

* Kocher's "Text-Book of Operative Surgery," translated by H. J. Stiles, 1903, p. 26. Publishers, A. & C. Black, London.

Given asepsis and a circumscribed aneurism with healthy vessel adjacent, there is no reason against ligaturing close up to the aneurism. This, besides with subclavian aneurism being probably the less serious operation, has the advantages of not interfering with the cerebral circulation and of not giving so great opportunities for the collateral circulation to restore pulsation in the sac. Probably in my own case ligature of the second part of the subclavian would have been sufficient to cure the patient, although the aneurism undoubtedly became smaller and harder as a result of the first operation. The usual surgical opinion that ligature of the first part of the subclavian is unjustifiable requires revision: the fatal cases have all been fatal from sepsis and hæmorrhage. Recently, Nassau, of St. Joseph's Hospital, Philadelphia, has successfully done the operation on the right,* and Stonham, of Westminster Hospital, on the left side.† Curtis's case (34) is a further example of successful ligature of the first part of the right subclavian.

Mode of Approach.—The central incision is the best. That it is applicable to large aneurisms is shown by Ballance's case. Where circumstances necessitate the opening of the anterior mediastinum, this should be done by longitudinal and transverse division of the manubrium sterni, as fully described by Curtis in his account of his case. Removal of bone is rarely necessary. A powerfully bladed double retractor with screw action, having its handles curved down over the chest, suggests itself as the best instrument for forcing the two halves of the bone apart. The operator works standing on the left side of the patient, near the patient's left shoulder, and looks downward into the wound.

Material of Ligature.—The ligature material must be certainly sterile and sufficiently strong to withstand the strain to which it is to be subjected. Too much importance has been

* Gould's "Year-Book of Medicine and Surgery," 1904; Surgery, p. 231.

† Lancet, London, August 2, 1902.

attached to the question of the best material for ligature, fatal results having been attributed by operators to defects in the ligature when they have really been due to septic infection at the site of ligature. Silk, as being strong and certainly sterilizable, is the best material. Whether floss-silk or Chinese twist does not matter.

Degree of Tightness of Ligature. Question of injuring Inner Coats.—Injury to the inner coats becomes a dangerous factor only when in addition to such injury sepsis is present. Even with a diseased innominate, as Burrell's case shows, the inner coat may safely be ruptured. Further, a study of the cases leads one to the conclusion that if the ligature is drawn tight, dividing, to some extent at all events, the inner coats, there is much less probability of pulsation returning in the aneurism. In the accounts of older cases (where one's general knowledge of the material and methods employed leads to the conclusion that in each a silk ligature was used drawn quite tightly) no mention is to be found of return of pulsation in the aneurismal sac, except in one (Lizars), and there it was quite transitory, and the reports of the necropsies indicate consolidation in the sac. In the later cases, on the contrary, where occlusion without rupture of coats was usually aimed at, return of pulsation has been frequent (Banks, Bennett May, Curtis, Sheen), necessitating secondary operations; and, further, the return of pulsation has been early, indicating that it has been due to a direct current of blood through the innominate at the site of ligature rather than to the establishmen of a collateral circulation. In Thomson's case, where the innominate was tied with "moderate firmness," a "chink" in the vessel at the site of ligature was found at the necropsy. The experimental work of W. G. Spencer, Delépine, and Dent * also supports the policy of tight ligature with division of the internal coats. If, however, the operator decides to aim at occlusion without rupture, two or more ligatures lying

* Delépine and Dent. Medico-Chirurgical Transactions, London, vol. lxxiv, 1891, p. 367.

side by side, and thus occluding the arterial lumen over a certain length (Ballance and Edmunds's method), are obviously better for this purpose than a single ligature.

Kind of Knot.—The first turn of either a reef or a surgical knot is liable to slip before the second turn is applied. In the "stay knot" of Ballance and Edmunds, two or more ligatures are placed side by side, round the vessel; in each is made in the same direction the first turn of a reef knot, then on each side the ends are gathered up together and treated as one strand in making the second turn. This knot is much less liable to slip than the others mentioned, but slipping to some extent is possible, particularly when only two strands are used, the "mutual support by friction and interlocking" not being sufficient to prevent such slipping. The stay knot, in my own case, either slipped, or else—a possibility, I think, unlikely from the force used—was not, in making the first turn, drawn sufficiently tight to close the vessel.

With all these knots the slipping of the first hitch is probably to a large extent brought about by the force of the blood pumped from the aorta. Some "breakwater" method, as Burrell terms it, is best to obviate this. Two strands are passed beneath the vessel if possible, half an inch or more apart. The first turn of a surgical or reef knot is then made in the proximal ligature and tightened, pulsation ceasing in the vessel beyond the tightened turn and in the aneurism. This first turn in the proximal ligature is then held tight, and the force of the pumping blood being thus taken off the part of the vessel encircled by the distal ligature, the latter ligature is completely tied by a surgical or reef knot. Finally, the second turn is taken in the proximal ligature and fixes it. This is a modification of Senn's method, which consists simply in placing two ligatures round the vessel and tying the one on the cardiac side first. Such a method was used in Burrell's and Curtis's cases and in my own for tying the subclavian. That this method is not always successful is shown by the return of pulsation in Curtis's case. The ligature on the cardiac side is liable to slip. Hence the modification that I have suggested.

An objection to this modification (not, I think, a great one) is that some part of the procedure has to be intrusted to an assistant. Any method involving two separate ligatures may be inapplicable owing to operative difficulties. I would put in order of preference the methods suitable for occlusion of the innominate after it has been exposed, as follows:

(*a*) Two separate ligatures tied as described above.

(*b*) The "stay knot," at least three strands being used.

(*c*) A single ligature tied in a surgical knot.

In all three cases I would draw the ligature so tightly that some amount of damage to the inner coats would be inflicted, this being particularly essential in the last method.

7. CONCLUSIONS.

1. That in properly selected cases ligature of the innominate is a reasonably safe and undoubtedly useful operation.

2. That suitable cases are those in which the aneurism is of a circumscribed, globular character, and the general condition of the patient is otherwise good. That unsuitable cases are those in which the aneurism is what is commonly called fusiform, but is really often nothing more than part of a general arterial dilatation, and in which there are marked signs of general arteriosclerosis with accompanying visceral disease.

3. That the maintenance of asepsis is the main factor in obtaining a successful result.

4. That the incision should be central with horizontal and vertical division of the manubrium, if necessary.

5. That the carotid should be tied as well as the innominate.

6. That silk is the best ligature material.

7. That some amount of injury to the inner coats is probably necessary to insure occlusion, but that with aseptic conditions such injury does not matter.

8. That two ligatures should if possible be placed round

the vessel, the first turn of the proximal ligature being held tight, so as to keep back the blood while the distal ligature is completely tied.

9. That the use of a drainage-tube is inadvisable.

10. That as a study of the recorded cases shows that, next to sepsis, some cerebral lesion has been the most frequent cause of death after operation, it would be well for future operators to consider the advisability of tying the carotid about a fortnight before the innominate.

11. That "Valsalvan" methods of treatment immediately prior to operation are inadvisable.

8. GENERAL REFERENCES.

N. B.—The words in brackets after certain references indicate the shortened form in which such references are given above in the special references after each case.

Ballance and Edmunds. Ligature in Continuity, 1891.

Burrell. Boston Medical and Surgical Journal, August 8, 1895. (Burrell.)

Crisp. Structure, Diseases, and Injuries of the Blood-Vessels. Jacksonian Prize Essay, London, 1847. (Crisp.)

Erichsen. Surgery, ninth edition, 1888, and tenth edition, 1895.

Jacobson. Operations of Surgery by Jacobson and Steward, 1902. (Jacobson.)

W. Koch. Langenbeck's Archiv für klinische Chirurgie, Band x, Heft 1, 1869. (Koch.)

Lefort. Dict. des Sciences Médicales, Paris, 1861.

Norris. Contributions to Practical Surgery, Philadelphia, 1873.

Poland. Guy's Hospital Reports, Series 3, vols. xv, xvi, xvii, 1870-1872. (Poland.)

Sabine. American Medical Times, New York, 1864.

Souchon. ANNALS OF SURGERY, November and December, 1895. (Souchon.)

Spencer, Brit. Med. Jour., 1889, vol. ii, p. 73. (W. G. Spencer.)

Thomson. On Ligature of the Arteria Innominata for Subclavian Aneurism, Dublin, 1883. Also Brit. Med. Jour., 1882, vol. ii, p. 722. (W. Thomson.)

Wyeth. Essays on Surgical Anatomy and Surgery, New York, 1879.

All the above authorities give lists or collections of cases.